SPECIFICATION

A lead frame and a semiconductor device made by use of the lead frame

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This invention relates to a lead frame and to a resin-molded semiconductor device manufactured by use of the lead frame.

Metallic lead frames have been used in the assembly of resin-molded semiconductor devices. The lead frame is a thin metal plate punched by a press or etched. Figure 1 of the accompanying drawings shows a previously proposed lead frame suitable for a semiconductor device of high packaging density and composed of a rectangular carrier member or tab 2 for mounting a semiconductor element, supporting or tab leads 3 which support the tab 2, a plurality of connection leads 4 which extend to near the peripheral edge of the tab 2, a rectangular frame portion 5 which supports the leads 4 and the tab connection leads 3, and a dam piece 6 which joins the frame portion 5, the leads 4 and the tab leads 3 together and which prevents the outflow of dissolved resin during the resin-molding operation. Guide holes 7 are provided at fixed intervals along both the side edges of the frame portion 5. During assembly of the device or transport of the lead frame, the guide holes 7 are used as locating holes or as engagement and transfer holes.

In assembly the device on such a lead frame, the semiconductor element 1 is mounted on the tab 2, and the electrodes of the element 1 and the inner ends of the connection leads 4 are connected by wires 8. Thereafter, an area 9 within the dam piece 6 is covered with the molded resin. Subsequently, the dam piece 6 and the frame portion 5 are cut off to obtain a semiconductor device having flat leads. Also, in order to obtain deal-in-line type devices, the connection leads 4 which protrude from the molded area 9 are bent through 90 degrees.

In such a semiconductor device, the problems discussed below have been found by the present inventors.

The tab is of low strength because it is supported at only two sides by the two fine tab leads. In order to keep the size of the device small in spite of recent increases in the number of connection leads, the widths of the leads and the tab leads are inevitably small. In order to form narrow leads (e.g. with widths of 0.3 mm) the thickness of the material of the lead frame is reduced to make punching easier. E.g. the thickness of the lead frame is approximately 0.15 mm. As a result, the tab is easily inclined or lifted by even a slight external force with respect to the leads, and this constitutes a hindrance in assembly. For example, the semiconductor element is mounted on the tab with a rubbing action by an element holding jig such as a collet, so that the tab moves with the resultant oscillations and the element and the tab are imperfectly bonded. As a result the element cracks when pushed by the flow of the resin during molding.

Moreover, in operation of the device thermal stress acts between a part where the element and the tab are perfectly bonded and a part in which they are imperfectly bonded, on account of heat generated by the element. This also results in the appearance of cracks in the element.

Also, in the resin molding, resin flows in towards the element 1 in the direction of arrow A of Figure 1. If, at this time, a corner 2a of the tab 2 is slanting downwards or upwards, the tab 2 is tilted more in the slant direction by the flow of resin. The tabe 2 is also pushed in the direction of arrow B by the resin. This results in breakage of the wires between the element and the lead or in contact between the wires. Furthermore, air bubbles remain in or on the molded body on account of the development of vortices ascribable to the inclination of the tab. This results in reduced moisture resistance or in hollows in the exterior causing inferior external appearance.

According to the present invention, there is provided a lead frame or sheet metal having a quadrangular carrier member for supporting a semiconductor element thereon; a frame portion; four supporting leads, each connected at one end to a respective corner of the carrier member and connected at the other end to the frame portion, the supporting leads respectively extending along a continuation of a line from the centre of the carrier member to a respective corner thereof; and a plurality of connection leads, each connected at one end to the frame portion and extending towards an inner end which lies adjacent an edge of the carrier member.

By this invention it is possible to provide a lead frame of excellent rigidity in which the semiconductor element carrier member does not move easily during assembly. The semiconductor devices produced with this lead frame can have excellent moisture-resistance and high reliability.

Embodiments of the invention will now be described by way of example with reference to the accompanying drawing, in which:-

Figure 1 is a plan view of the prior-art lead frame discussed above,

Figure 2 is a plan view of a lead frame embodying this invention.

Figure 3 is a plan view of a semiconductor device employing the lead frame of Figure 2,

Figures 4 and *5* are enlarged views of parts of the device of Figure 3,

Figure 6 is a plan view of another lead frame embodying this invention,

Figure 7 is an enlarged perspective view of a tab lead in the lead frame of Figure 6,

Figures 8 and *9* are schematic views for explaining the separation of the device of Figure 6 from the frame portion of the lead frame.

Figure 10 is an enlarged plan view illustrating the resin molded area of the lead frame of Figure 6, and

Figure 11 is a sectional view taken along the line A-A of Figure 10.

The lead frame of Figure 2 is fabricated by punching or etching a metal sheet made of an Fe-Ni-Co alloy or an Fe-Ni alloy and 0.15 mm thick. A rectangular carrier member or tab 12 for mounting a semiconductor element (pellet) lies in the center of a frame portion 10 which is generally rectangular

though it has different widths at some places. The tab 12 has its four corners coupled to the frame portion 10 by four fine supporting or tab leads 13 which extend radially. A plurality of connection leads 14 extend towards the four peripheral edges of the tab 12 (only two such connection leads 14 being shown for clarity) and each terminates in the vicinity of the tab 12. The other end of each of these connection leads 14 is connected to the frame portion 10.

In order to check the outflow of dissolved resin during resin molding, first support strips, herein called dam pieces 15, are disposed between adjacent pairs of leads 14. The frame portion 10 is provided with guide holes 16. L-shaped holes L_1, L_2 and L_3 lie close to the tab leads 13. Elongated holes M_1, M_2, M_3 and M_4 are near the ends of the connection leads 14 connected to the frame portion 10. The purposes of these holes will be described later. Figure 2 shows the lead frame used in one semiconductor device though in practice such frames are formed repeatingly in a long narrow strip. At their outer ends, the connection leads 14 are supported and interconnected by a second support strip 31 which connects them to the frame.

The semiconductor device incorporating this lead frame is assembled in the following manner.

First, as illustrated in Figure 3, the semiconductor element (pellet) 11 is directly bonded onto the tab 12. This element 11 is made of silicon material, and is formed with a plurality of transistors. In edge regions of the upper surface of the element 11, aluminium bonding pads P_1, P_2 ... which are to be connected with the connection leads 14 by gold (Au) wires, are present in substantially the same number as the number of connection leads 14.

To bond the element 11 onto the tab 12, the element 11, with its face in which the bonding pads are disposed uppermost is picked up by a jig called a "collet". While the collet is vibrated, the element 11 is bonded onto the heated surface of the tab 12 on which a gold foil 30 has been deposited. Since the element 11 is made of silicon it forms a eutectic alloy with the gold foil and is perfectly bonded onto the surface of the tab 12.

Subsequently, the aluminium bonding pads P_1, P_2 ... and the ends of the connection leads 14 close to the tab 12 are connected to each other by the Au wires w_1, w_2 ....

Thereafter, a resin such as an epoxy resin is poured in the direction of arrow C, to envelop the connection leads 14, the tab 12, the tab leads 13, the Au wires w_1, w_2 .... and the element 11 which lie within the dam pieces 15 in a protective body of the resin. The chain dot line 17 indicates the area over which the resin is molded. As Figure 4 clearly shows, the corner portion 18, of the area 17 intesecting the tab lead 13 is bevelled so that it orthogonally intersects the tab lad 13. This prevents the corners of the molded area 17 being cut by a lead cutter when the tab leads are later cut at their roots.

Where hatched in Figure 3, the dam pieces 15 and the support strip 31 of the connection leads 14 are then cut off. Since the tab leads 13 are not separated from the frame portion 10 at this stage, the semiconductor device comprising the molded body 17 and the connection leads 14 is still supported by the frame portion 10.

The semiconductor device has its electrical characteristics tested in this condition and marks indicative of grade etc. are printed on the upper surface of the molded body 17. Thereafter, the device is separated from the frame portion 10 by cutting the tab leads 13 at the corners 18.

When fabricating deal-in-line type semiconductor devices in which the connection leads 14 protruding from the molded body 17 are bent through 90 degrees the bending of the connection leads 14 is carried out simultaneously with the cutting of the tab leads 13.

With the lead frame described above, the following results are achieved:

(A) Since the rectangular tab 12 is supported by the four tab leads 13 which extend along the diagonal lines of the tab 12, the tab 12 is difficult to move into an inclined position and has excellent rigidity. The advantages are that:

(1) When automatically attaching the element 11 to the tab 12, the desired location of the element 11 relative to the tab 12 is reliably obtained. Thus, the bonding of the wires w_1, w_2 ...to the bonding pads P_1, P_2 ... and the connection leads 14 may also be executed reliably. Even for a device which has a plurality of closely adjacent leads, the automation of the mounting of the element 11 (pellet bonding) and of the wire bonding is very easy with this lead frame structure of this invention.

(2) When attaching the element 11 to the tab 12 by rubbing the two together using the carrying element jig, the tab does not pivot. Accordingly element 11 and the tab 12 are perfectly bonded. This minimizes the risk that cracks appear in the element.

(3) Since the resin is poured from the vicinity of one tab lead 13 as indicated by the arrow C in Figure 3, the tab 12 does not become inclined, so that intense forces are not applied to the wires which might break the wires or bring the wires into contact with each other.

(4) During the resin molding, the tab is not caused to incline by the inflowing resin, and vortices attributable to the flow do not develop either. Air bubbles in the interior of the molding portion 17 or at its surface are avoided. In consequence, even when the resin is thin, an excellent semiconductor device is produced without reduction of moisture-resistance or a poor exterior view.

(B) The holes L_1. L_2, L_3, M_1,M_2,M_3 and M_4 are provided near the ends of the tab leads connection 13 and the connection leads 14 remote from the tab 12. Accordingly, during the hardening of the resin, the frame portion 10 can be prevented from being drawn towards the tab 12. Therefore, neither kinking nor warping develops in the lead frame, and the location of the lead frame or its transfer using the guide holes 16 is not rendered difficult.

(C) After the dam pieces 15 and the ends 31 of the connection leads 14 have been cut the semiconductor device is supported by the frame portion 10 through the tab leads 13. As a result, the ensuing advantages are achieved:

(1) When testing the electrical characteristics of the device and marking it, the transfer using the guide holes 16 of the lead frame is possible. Thus the tests and the marking can be continuously performed and efficiency is enhanced.

(2) A plurality of the semiconductor devices are handled when regularly arrayed on a single sheet of lead frames. The devices do not get entangled with each other, and breakage of the leads, etc. does not occur either.

(3) The devices can be transported by carrying the frame portion 10 of the lead frame. Therefore the leads are not directly touched, and breakage of the leads, etc. do not occur. Especially if the molded element is composed of a plurality of MOS transistors which are liable to electrostatic breakdown this breakdown is preventable.

Modifications of the embodiment shown above will be described now.

(a) Figure 4 shows a V-shaped groove 20 in the tab lead 13, so that the tab lead 13 can be easily cut at the groove. In addition the groove 20 prevents the tab lead from being pulled out when being cut by the lead cutter.

In the absence of such a groove 20, the tab lead is liable to fall out when being cut, and a semiconductor device of high reliability will not be obtained because of inferior moisture-resistance. More specifically, as Figure 2 shows, the tab lead 13 extends straight from the tab 12, and its width is very small at the junction of the tab 12 and the tab lead 13. Accordingly, when the tab lead 13 is pulled by the lead cutter in the cutting step, this junction may snap, causing the tab lead to fall out, so lowering moisture resistance. Even if this junction does not snap, the tab lead 13 may be pulled out considerably, and a vacant space may appear between it and the resin, so reducing moisture resistance.

(b) At least one of the tab leads may be used as an earth lead. As Figure 5 shows, the tab lead 13 can be extended parallel to the connection leads 14, for this purpose.

(c) In the embodiment of Figure 2, the corners 18 of the molded body 17 are cut away as shown in Figure 4. In order to obtain this chamfered or bevelled structure, a mold for the resin corresponding to the structure must be used. The mold of this shape is expensive because its manufacture is very difficult. To avoid this, the lead frame shown in Figure 6 has a structure such that the corners of the molded area are not chamfered. Each of the tab leads 13 is in a Y-shape with two branch leads 19 near the frame portion 10. Figure 7 shows this enlarged. V-shaped grooves 20 in the branch leads 19 facilitate the separation of the tab lead 13 from the frame portion 10.

The molded area is indicated by chain-dot line 17 in Figure 6. The branch leads 19 are later cut where indicated by double-dot chain-dot lines 32 in Figure 8 at the grooves 20. Although the element 11 and the wires are not shown in Figure 6, they are disposed on the lead frame in the same way as in Figure 3.

In the lead frame having tab leads as shown in Figures 6 and 7 accordingly, the corners of the molded body are not cut by the lead cutter when cutting the tab leads. Also, there is less risk of the tab leads being pulled out when being cut. Figure 9 shows that a part 17' of the molded resin exists between the two branch leads 19, and this part 17' supports the tab lead 13 against being pulled towards the frame portion 10 (in the direction of arrrow D) when the leads 19 are cut. Consequently, a semiconductor device of high moisture-resistance can be achieved.

Also, with this lead frame, the resin pouring gate portion is improved. Referring to Figure 6, the resin flows in towards the tab 12 through a resin pouring portion 21. That space (hole) in the portion 21 which is enclosed with the branch leads 19 and the frame portion 10 is larger than the holes in the other corners 40, 41 and 42. As a result an adequate resin flows towards the tab 12 can be achieved. This avoids the risk of exposure of the element 11 or the wire, because of insufficient inflow of the resin. This point will now be explained with reference to Figures 10 and 11, which show resin mold parts 50 and 50' partly (at 51) lying in contact with the lead frame and partly (at 52) not contacting with the lead frame. The resin flows into the space 52 through the hole 21, to form the molded body of the semiconductor device. The resin flows into the space 52 sufficiently because as Figure 11 shows, the frame portion 10 is absent in a resin pouring port 54 of the mold parts 50 and 50'. Thus the lead frame is held between mold parts 50 and 50' so that the port 54 lies at the hole 21.

If the frame portion 10 were not absent at the port 54, as indicated by broken lines 10', the width w_1 of the resin pouring port 54 is smaller by the thickness of the lead frame and the resin 17 does not sufficiently flow into the space 52. To avoid this defect, the width w_1 of the port 54 may be made greater in dependence on the thickness of the lead frame. In this case, however, it is difficult to fabricate a semiconductor device having a thin molding portion.

Furthermore, a stepped part 60 is formed in a runner 22 as illustrated in Figure 11, so that when the molded body and the runner 22 are to be separated, a stress concentration acts on the stepped part 60 with the result that separation occurs in the stepped part 60. As a result, the shapes of runner separation parts in the molded articles are uniform, and the disadvantage of irregular separation parts is avoidable.

CLAIMS

1. A lead frame of sheet metal having a quadrangular carrier member for supporting a semiconductor element thereon; a frame portion; four supporting leads, each connected at one end to a respective corner of the carrier member and connected at the other end to the frame portion, the supporting leads respectively extending along a continuation of a line from the centre of the carrier member to a respective corner thereof; and a plurality of connection leads, each connected at one end to the frame portion and extending towards an inner end which lies adjacent an edge of the carrier member.

2. A lead frame according to claim 1, wherein the

(1) When testing the electrical characteristics of the device and marking it, the transfer using the guide holes 16 of the lead frame is possible. Thus the tests and the marking can be continuously performed and efficiency is enhanced.

(2) A plurality of the semiconductor devices are handled when regularly arrayed on a single sheet of lead frames. The devices do not get entangled with each other, and breakage of the leads, etc. does not occur either.

(3) The devices can be transported by carrying the frame portion 10 of the lead frame. Therefore the leads are not directly touched, and breakage of the leads, etc. do not occur. Especially if the molded element is composed of a plurality of MOS transistors which are liable to electrostatic breakdown this breakdown is preventable.

Modifications of the embodiment shown above will be described now.

(a) Figure 4 shows a V-shaped groove 20 in the tab lead 13, so that the tab lead 13 can be easily cut at the groove. In addition the groove 20 prevents the tab lead from being pulled out when being cut by the lead cutter.

In the absence of such a groove 20, the tab lead is liable to fall out when being cut, and a semiconductor device of high reliability will not be obtained because of inferior moisture-resistance. More specifically, as Figure 2 shows, the tab lead 13 extends straight from the tab 12, and its width is very small at the junction of the tab 12 and the tab lead 13. Accordingly, when the tab lead 13 is pulled by the lead cutter in the cutting step, this junction may snap, causing the tab lead to fall out, so lowering moisture resistance. Even if this junction does not snap, the tab lead 13 may be pulled out considerably, and a vacant space may appear between it and the resin, so reducing moisture resistance.

(b) At least one of the tab leads may be used as an earth lead. As Figure 5 shows, the tab lead 13 can be extended parallel to the connection leads 14, for this purpose.

(c) In the embodiment of Figure 2, the corners 18 of the molded body 17 are cut away as shown in Figure 4. In order to obtain this chamfered or bevelled structure, a mold for the resin corresponding to the structure must be used. The mold of this shape is expensive because its manufacture is very difficult. To avoid this, the lead frame shown in Figure 6 has a structure such that the corners of the molded area are not chamfered. Each of the tab leads 13 is in a Y-shape with two branch leads 19 near the frame portion 10. Figure 7 shows this enlarged. V-shaped grooves 20 in the branch leads 19 facilitate the separation of the tab lead 13 from the frame portion 10.

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Furthermore, a stepped part 60 is formed in a runner 22 as illustrated in Figure 11, so that when the molded body and the runner 22 are to be separated, a stress concentration acts on the stepped part 60 with the result that separation occurs in the stepped part 60. As a result, the shapes of runner separation parts in the molded articles are uniform, and the disadvantage of irregular separation parts is avoidable.

CLAIMS

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2. A lead frame according to claim 1, wherein the

plurality of connection leads associated with each side of the carrier member are interconnected for mutual support by first support strips.

3. A lead frame according to claim 2, wherein the plurality of connection leads associated with each side of the carrier member have their other ends connected to the frame portion by a second support strip.

4. A lead frame according to any one of the preceding claims, wherein each of the supporting leads has a transverse groove at which it is to be severed.

5. A lead frame according to claim 4, wherein said groove is V-shaped in section.

6. A lead frame according to any one of Claims 1 to 3, wherein the other end of each of the supporting leads is connected to said frame portion by two branch tabs.

7. A lead frame according to claim 6, wherein each of said branch tabs has a transverse groove at which it is to be severed.

8. A lead frame according to claim 7, wherein said groove is V-shaped in section.

9. A lead frame for use in the manufacture of a semiconductor device substantially as herein described with reference to and as shown in Figure 2 or Figure 6 of the accompanying drawings.

10. A semiconductor device made with use of a lead frame according to any one of claims 1 to 9.

11. A semiconductor device substantially as herein described with reference to and as shown in Figure 3 of the accompanying drawings.

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